fiber 11, considering the possibility that the optical isolator itself is a cause of loss, the input light level to the rare earth-doped optical fiber 11 is increased. For example, if we assume that the loss in the optical isolator is 0.5 dB, by removing that optical isolator the input light level to the rare earth-doped optical fiber 11 is increased by 0.5 dB. Consequently, even if the gain of the rare earth-doped optical fiber 11 is decreased by an amount equal to the loss in the optical isolator, the input light level can still be monitored accurately.

The optical band pass filter 72 shown in FIG. 15 and FIG. 16 is a filter that passes the wavelength components that carry the signal. For example, in a light transmission system using signal light in the 1550 nm band, the signal is often actually carried on light of wavelength 1552 nm or 1557 nm, but the lasers used in 1550 m band light transmission systems normally have a peak of light intensity in the vicinity of 1530 nm. In this case, the optical band pass filter 72 passes light of the wavelength of, for example, 1545 nm to 1565 nm, while cutting off light of the wavelengths in the vicinity of 1530 nm. In this kind of configuration, a drop in the gain of the rare earth-doped optical fiber caused by emission of light in the 1530 nm band can be prevented.

In FIG. 15 and FIG. 16, the optical band pass filter 72 is placed on the output side of the rare earth-doped optical fiber 12, but it can also be placed between the rare earth-doped optical fiber 11 and the rare earth-doped optical fiber 12. However, if the optical band pass filter 72 is placed between the rare earth-doped optical fiber 11 and the rare earth-doped optical fiber 12, it is necessary to use such a configuration that the excitation light will not be cut off by the optical band pass filter 72. An optical notch filter can be used in place of the optical band pass filter.

The optical amplifier shown in FIG. 15 is of forward-excitation configuration, with the excitation light supplied from the input sides of the rare earth-doped optical fibers 11 and 12.

In the configuration shown in FIG. 16, the splitter 73 branches the light output from the laser light source 74 in order to supply excitation light to the rare earth-doped optical fibers 11 and 12. The excitation light branched by the splitter 73 is guided by the respective optical couplers (wavelength division multiplexing couplers) 75 and 76, and supplied to the rare earth-doped optical fibers 11 and 12. Excitation light is supplied from the output side of the rare earth-doped optical fiber 11 and from the input side of the rare earth-doped optical fiber 12.

The optical amplifier shown in FIG. 17 is of such a configuration that excitation light is supplied from the output sides of the rare earth-doped optical fibers 11 and 12. Excitation light output from the laser light source 77 cannot pass through the optical isolator 21*a* in the reverse direction, so the configuration is such that the splitter 78 and the optical coupler 79 are used to make the excitation light bypass the optical coupler 21*a*. The splitter 78 and the optical coupler 79 are realized by, for example, respective wavelength-division multiplexing couplers.

In the above embodiments, the configurations were described assuming that the excitation light stops when the input light level drops below a threshold level, but it is also possible to have configurations in which the excitation light power is reduced. In particular, in the configurations shown in FIG. 10 and FIG. 15, in a case in which the excitation light is input to a rare earth-doped optical fiber in one stage and then is incident upon a rare earth-doped optical fiber in a succeeding stage, it is possible that even if the excitation light power is small, the rare earth-doped optical fiber in the first stage will go into the excited state. For this reason, if the excitation light power is reduced when the input light level drops below a threshold level, it is possible to put the rare earth-doped optical fiber in the first stage into the excited state and obtain gain, while suppressing the power consumption. In turn, if gain can be obtained in the rare earth-doped optical fiber in the first stage, the transition of the input light from not containing a signal to containing a signal can be reliably detected.

In addition, in the above embodiments, configurations in which the input light is amplified using rare earth-doped optical fibers have been described, but this invention is not limited to such a configuration; it is also possible to have a configuration in which an auxiliary amplifier having gain larger than the loss that occurs in the device that monitors the input light level is used in a stage preceding the main amplifier that amplifies the input light to the desired level.

This invention uses two rare earth-doped optical fibers in successive stages in an optical amplifier having an input light level monitoring function. The gain of the rare earth-doped optical fiber in the first stage is made larger than the loss that occurs in the device that monitors the input light level, so that the input light level can be monitored without amplifying the input side loss, contributing to reducing the noise in the optical amplifier and making transmission over longer distances possible.

In addition, this invention makes it possible to achieve the optimum dispersion compensation to match the transmission path. This also contributes to reducing the noise in the optical amplifier and making transmission over longer distances possible.

What is claimed is:

1. An optical amplifier comprising:

an optical fiber through which an input light travels, the input light being amplified as the input light travels through the optical fiber via first pumping light traveling through the optical fiber in an opposite direction than the input light;

an optical splitter splitting off a portion of the amplified input light, the first pumping light being controlled in accordance with a monitored optical power of said split portion; and

an optical fiber amplifier, optically connected to the optical splitter, amplifying the input light having said portion split off therefrom via second pumping light.

2. An optical amplifier according to claim 1, wherein the optical fiber amplifier is a rare earth-doped optical fiber amplifier.

3. An optical fiber amplifier according to claim 1, further comprising an optical isolator between the optical splitter and the optical fiber amplifier.

4. An optical fiber amplifier according to claim 1, further comprising:

a monitor monitoring the optical power of said split portion, to thereby provide said monitored optical power.

5. An optical fiber amplifier according to claim 2, further comprising:

a monitor monitoring the optical power of said split portion, to thereby provide said monitored optical power.

6. An optical fiber amplifier according to claim 3, further comprising:

a monitor monitoring the optical power of said split portion, to thereby provide said monitored optical power.

7. An optical amplifier comprising:

an optical fiber through which an input light travels, the input light being amplified as the input light travels through the optical fiber via first pumping light traveling through the optical fiber in an opposite direction than the input light;

an optical splitter splitting off a portion of the amplified input light, the first pumping light being controllable in accordance with a monitored optical power of said split portion; and

an optical fiber amplifier, optically connected to the optical splitter, amplifying the input light having said portion split off therefrom via second pumping light.

8. An optical amplifier comprising:

an optical fiber through which an input light travels, the input light being amplified as the input light travels through the optical fiber via first pumping light traveling through the optical fiber in an opposite direction than the input light;

an optical splitter splitting off a portion of the amplified input light, the first pumping light being controlled in accordance with a monitored optical power of said split portion; and

an optical fiber amplifier amplifying the input light having said portion split off therefrom via second pumping light.

9. An optical amplifier according to claim 8, wherein the optical fiber amplifier is a rare earth-doped optical fiber amplifier.

10. An optical fiber amplifier according to claim 8, further comprising an optical isolator between the optical splitter and the optical fiber amplifier.

11. An optical fiber amplifier according to claim 8, further comprising:

a monitor monitoring the optical power of said split portion, to thereby provide said monitored optical power.

12. An optical fiber amplifier according to claim 9, further comprising:

a monitor monitoring the optical power of said split portion, to thereby provide said monitored optical power.

13. An optical fiber amplifier according to claim 10, further comprising:

a monitor monitoring the optical power of said split portion, to thereby provide said monitored optical power.

14. An optical amplifier comprising:

an optical fiber through which an input light travels, the input light being amplified as the input light travels through the optical fiber via first pumping light traveling through the optical fiber in an opposite direction than the input light;

an optical splitter splitting off a portion of the amplified input light, the first pumping light being controllable in accordance with a monitored optical power of said split portion; and

an optical fiber amplifier amplifying the input light having said portion split off therefrom via second pumping light.

15. An apparatus comprising:

an optical amplifier including

an optical fiber through which an input light travels, the input light being amplified as the input light travels through the optical fiber via first pumping light traveling through the optical fiber in an opposite direction than the input light,

an optical splitter splitting off a portion of the amplified input light, the first pumping light being controlled in accordance with a monitored optical power of said split portion; and

an optical fiber amplifier amplifying the input light having said portion split off therefrom via second pumping light.

16. An apparatus comprising:

an optical amplifier including

an optical fiber through which an input light travels, the input light being amplified as the input light travels through the optical fiber via first pumping light traveling through the optical fiber in an opposite direction than the input light,

an optical splitter splitting off a portion of the amplified input light, the first pumping light being controlled in accordance with a monitored optical power of said split portion; and

an erbium doped fiber amplifier (EDFA) including an erbium doped fiber (EDF) through which the input light having said portion split off therefrom travels and is amplified via second pumping light traveling through the EDF.

17. An apparatus comprising:

an optical amplifier including

an optical fiber through which an input light travels, the input light being amplified as the input light travels through the optical fiber via first pumping light traveling through the optical fiber in an opposite direction than the input light,

means for splitting off a portion of the amplified input light, the first pumping light being controlled in accordance with a monitored optical power of said split portion; and

an optical fiber amplifier amplifying the input light having said portion split off therefrom via second pumping light.

18. An apparatus comprising:

an optical amplifier including

an optical fiber through which an input light travels, the input light being amplified as the input light travels through the optical fiber via first pumping light traveling through the optical fiber in an opposite direction than the input light,

means for splitting off a portion of the amplified input light, the first pumping light being controlled in accordance with a monitored optical power of said split portion; and

an erbium doped fiber amplifier (EDFA) including an erbium doped fiber (EDF) through which the input light having said portion split off therefrom travels and is amplified via second pumping light traveling through the EDF.

19. An apparatus comprising:
an optical splitter splitting off a portion of an input light having been amplified as the input light traveled through an optical fiber via first pumping light traveling through the optical fiber in an opposite direction than the input light, the first pumping light being controlled in accordance with a monitored optical power of said split portion; and
an optical fiber amplifier, optically connected to the optical splitter, amplifying the input light having said portion split off therefrom via second pumping light.

20. An apparatus according to claim 19, wherein the optical fiber amplifier is a rare earth-doped optical fiber amplifier.

21. An apparatus according to claim 19, further comprising an optical isolator between the optical splitter and the optical fiber amplifier.

22. An apparatus according to claim 19, further comprising:
a monitor monitoring the optical power of said split portion, to thereby provide said monitored optical power.

23. An apparatus according to claim 20, further comprising:
a monitor monitoring the optical power of said split portion, to thereby provide said monitored optical power.

24. An apparatus according to claim 21, further comprising:
a monitor monitoring the optical power of said split portion, to thereby provide said monitored optical power.

25. An apparatus according to claim 19, wherein the optical fiber is an erbium doped fiber.

26. An apparatus according to claim 19, wherein there are no optical components between the optical splitter and the optical fiber amplifier.

27. An apparatus comprising:
an optical splitter splitting off a portion of an input light having been amplified as the input light traveled through an optical fiber via first pumping light traveling through the optical fiber in an opposite direction than the input light, the first pumping light being controlled in accordance with a monitored optical power of said split portion; and

an optical fiber amplifier amplifying the input light having said portion split off therefrom via second pumping light.

28. An apparatus according to claim 27, wherein the optical fiber amplifier is a rare earth-doped optical fiber amplifier.

29. An apparatus according to claim 27, further comprising an optical isolator between the optical splitter and the optical fiber amplifier.

30. An apparatus according to claim 28, further comprising:
a monitor monitoring the optical power of said split portion, to thereby provide said monitored optical power.

31. An apparatus according to claim 29, further comprising:
a monitor monitoring the optical power of said split portion, to thereby provide said monitored optical power.

32. An apparatus according to claim 27, wherein the optical fiber is an erbium doped fiber.

33. An apparatus according to claim 27, wherein there are no optical components between the optical splitter and the optical fiber amplifier.

34. An apparatus comprising:
an optical splitter splitting off a portion of an input light having been amplified via first pumping light traveling in an opposite direction than, and along the same travel path as, the input light, the first pumping light being controlled in accordance with a monitored optical power of said split portion; and
an optical fiber amplifier, optically connected to the optical splitter, amplifying the input light having said portion split off therefrom via second pumping light.

35. An apparatus according to claim 34, further comprising an optical isolator between the optical splitter and the optical fiber amplifier.

36. An apparatus according to claim 34, further comprising:
a monitor monitoring the optical power of said split portion, to thereby provide said monitored optical power.

37. An apparatus according to claim 35, further comprising:
a monitor monitoring the optical power of said split portion, to thereby provide said monitored optical power.

38. An apparatus according to claim 34, wherein there are no optical components between the optical splitter and the optical fiber amplifier.

39. An optical amplifier according to claim 1, wherein the optical fiber is doped with a rare earth element.

40. An optical amplifier according to claim 7, wherein the optical fiber is doped with a rare earth element.

41. An optical amplifier according to claim 8, wherein the optical fiber is doped with a rare earth element.

42. An optical amplifier according to claim 14, wherein the optical fiber is doped with a rare earth element.

43. An apparatus according to claim 15, wherein the optical fiber is doped with a rare earth element.

44. An apparatus according to claim 16, wherein the optical fiber is doped with a rare earth element.

45. An apparatus according to claim 17, wherein the optical fiber is doped with a rare earth element.

46. An apparatus according to claim 18, wherein the optical fiber is doped with a rare earth element.

47. An apparatus for receiving an optical signal transmitted through an optical fiber in a first direction, comprising:
a pumping light source to output a pumping light to the optical fiber so that the pumping light travels through the optical fiber in a second direction opposite to the first direction;
an optical coupler to receive the optical signal from the optical fiber and to output the received optical signal and a monitor signal of the received optical signal, the pumping light source being controlled in accordance with the monitor signal to thereby control the pumping light output by the pumping light source; and

an optical amplifier to amplify the received optical signal output from the optical coupler.

48. An apparatus according to claim 47, wherein the optical fiber is doped with a rare earth element.

49. An optical transmission system, comprising:
an optical transmitting station to transmit an optical signal through an optical fiber in a first direction; and
an optical repeater, coupled to the optical fiber, including:
a pumping light source to output a pumping light to the optical fiber so that the pumping light travels through the optical fiber in a second direction opposite to the first direction,
an optical coupler to receive the optical signal from the optical fiber and to output the received optical signal and a monitor signal of the received optical signal, the pumping light source being controlled in accordance with the monitor signal to thereby control the pumping light output by the pumping light source and
an optical amplifier to amplify the received optical signal from the optical coupler and to output the amplified optical signal.

50. An optical transmission system, according to claim 49, wherein the optical fiber is doped with an rare earth element.

51. An optical transmission system, comprising:
an optical repeater, coupled to an optical fiber through which an optical signal is transmitted in a first direction, including:
a pumping light source to output a pumping light to the optical fiber so that the pumping light travels through the optical fiber in a second direction opposite to the first direction,
an optical coupler to receive the optical signal from the optical fiber and to output the received optical signal and a monitor signal of the received optical signal, the pumping light source being controlled in accordance with the monitor signal to thereby control the pumping light output by the pumping light source, and
an optical amplifier to amplify the received optical signal output from the optical coupler; and

an optical receiver, operatively coupled to the optical repeater, to receive the amplified optical signal.